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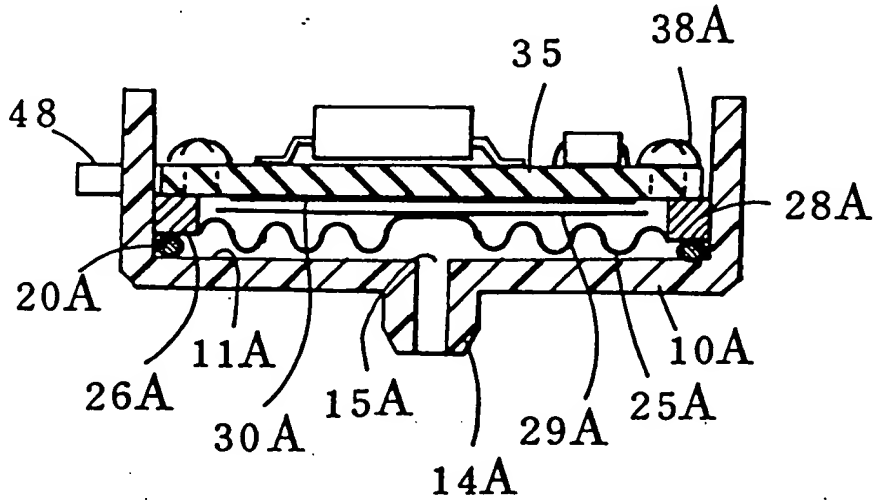
Selected US specifications from IPC sub-class G01L

(54) Pressure sensor

(57) A capacitance pressure sensor comprises a housing (10A) and a bellows (25A) against which the pressure acts via pressure input (14A). The pressure is determined by measuring the capacitance between a movable electrode (29A), attached to the bellows and a fixed electrode (30A) secured to the undersurface of printed circuit board (35) forming part of the housing. The spacing between the two electrodes is defined by a removable spacing ring (28A) interposed between the fixed electrode and the bellows, allowing the sensor to be both small and accurate.

FIG. 6



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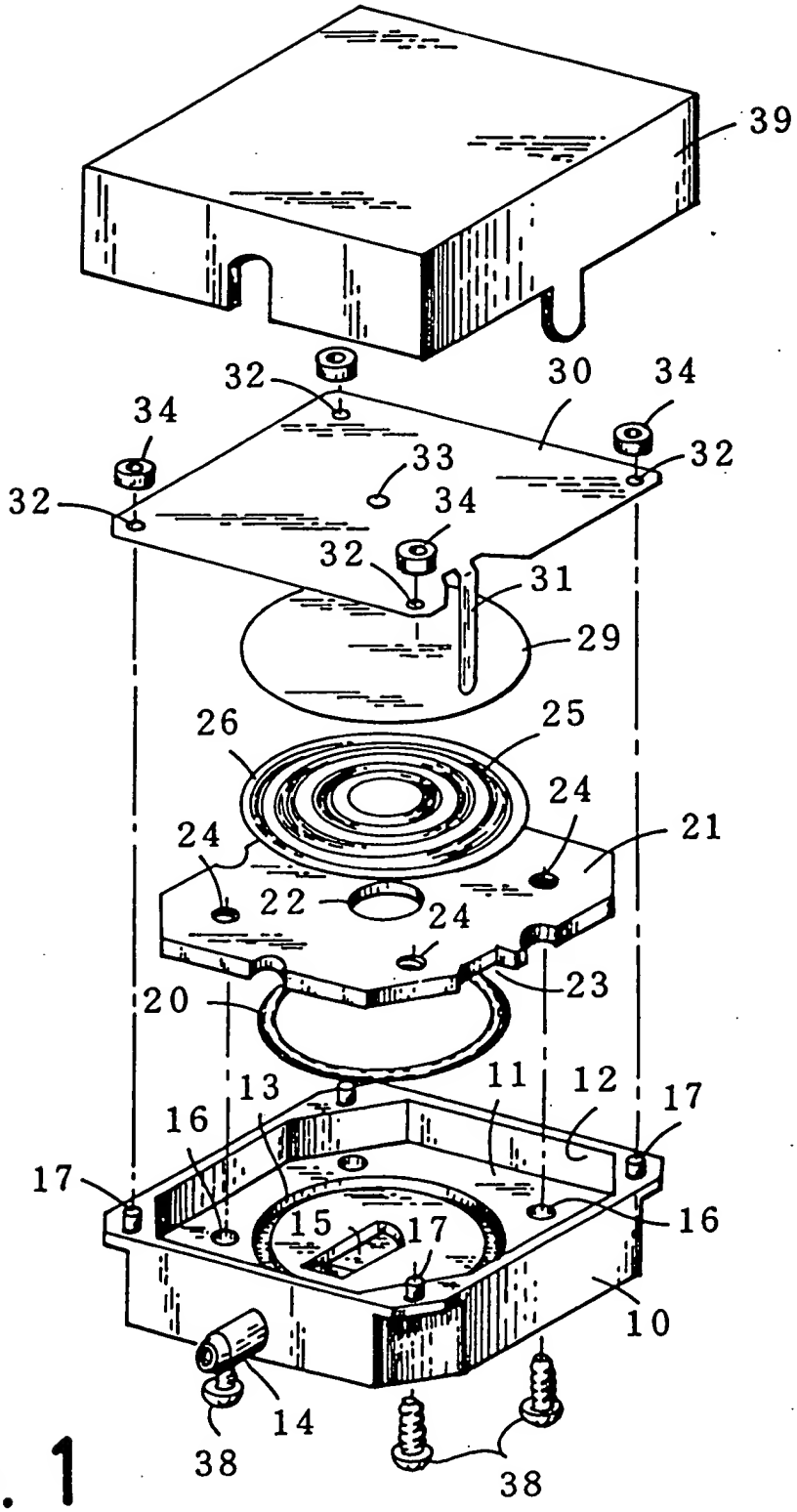

FIG. 1
PRIOR ART

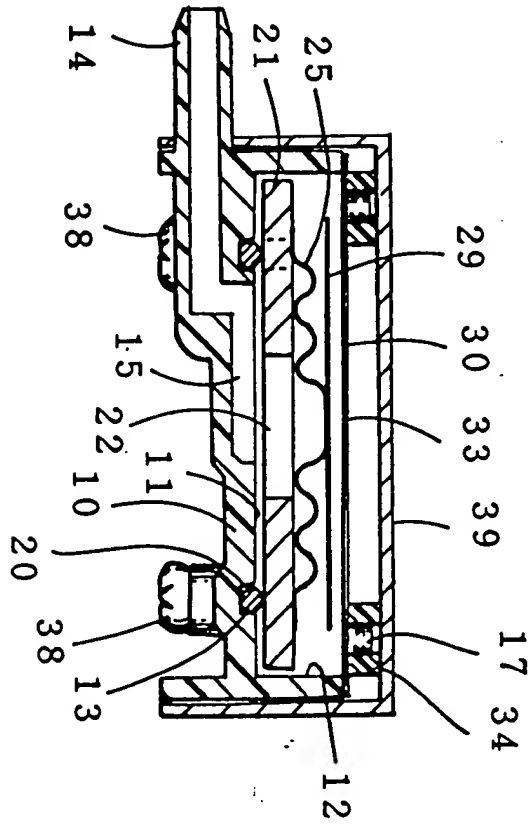

FIG. 2
PRIOR ART

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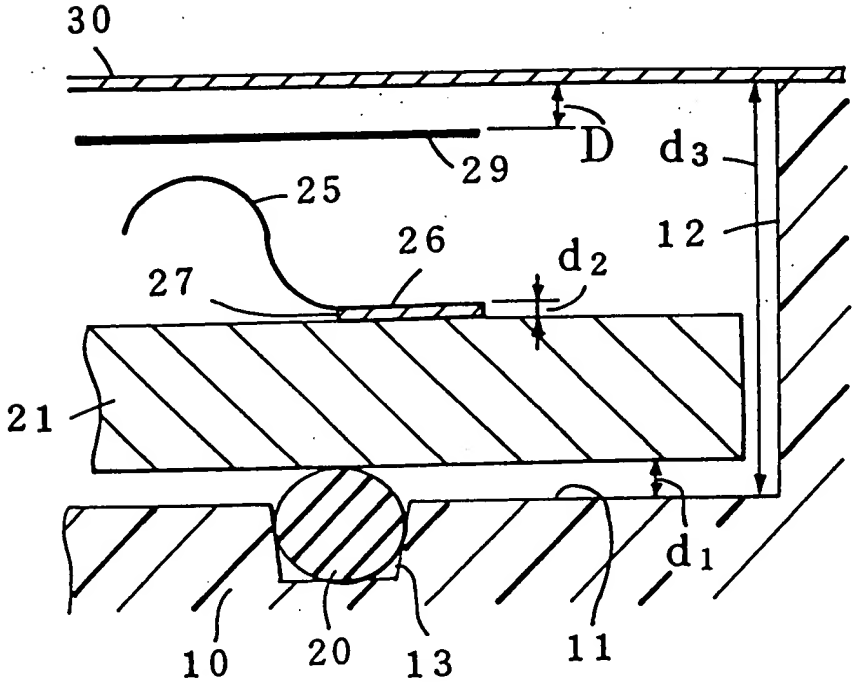
FIG. 3
PRIOR ART



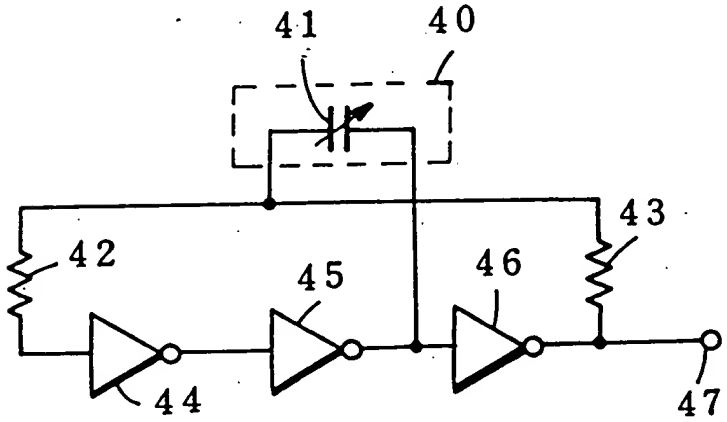


FIG. 4
PRIOR ART

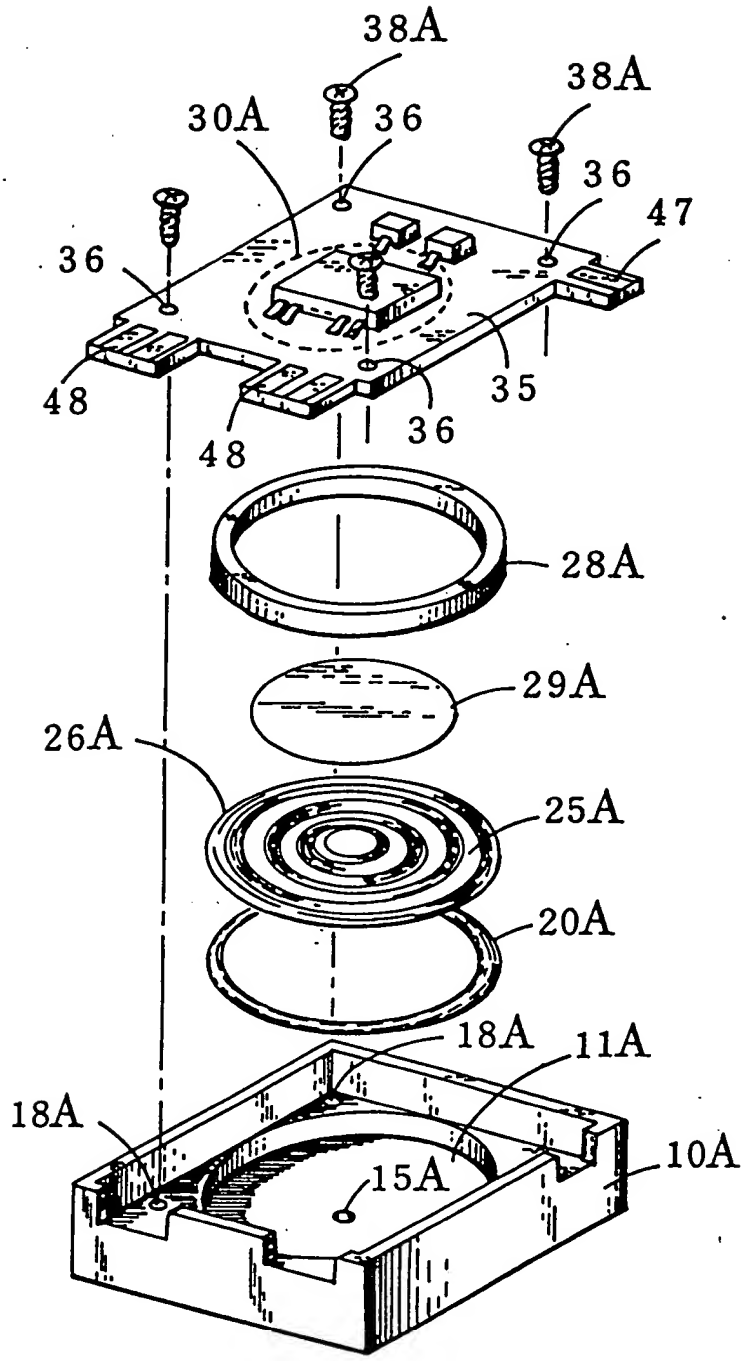

38A
38A
30A
36
36
36
47
36
48
48
36
35
28A
29A
26A
25A
20A
18A
11A
18A
10A
15A

FIG. 5

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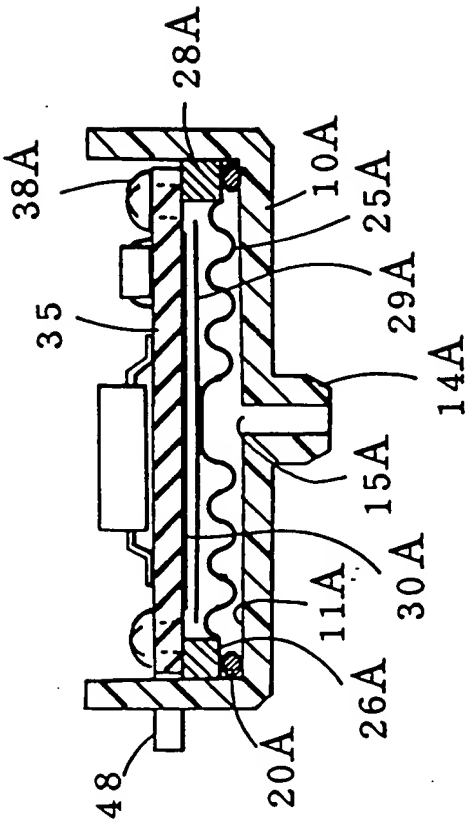

FIG. 6

SPECIFICATION

Pressure sensor

This invention relates to a pressure sensor. Particularly, this invention is intended to provide an improved pressure sensor including a moveable electrode plate mounted on a bellows and a fixed electrode plate in which both plates form a capacitance which is varied by variation of pressure.

A conventional pressure sensor is shown in Figures 1 to 4: Figure 1 is an exploded view in perspective of the conventional pressure sensor, Figure 2 is a sectional side view of the same, Figure 3 is a detailed portion sectional side view and Figure 4 is a circuit diagram for detecting varitions of pressure.

In those figures, reference numeral 10 indicates a housing, 11 identifies a base which is inside the housing 0, 12 denotes an upstanding portion which rises from the base 11, 13 designates an O ring groove, 20 represents an O ring which is used for obtaining a hermetically sealed space by being inserted into the O ring groove 13, 14 shows a pressure input (from which the pressure to be measured is supplied), 15 refers to a pressure hole which introduces the pressure to be measured to the sealed space inside the housing 10, 16 idicates four through-holes through which four screws 38 pass, and 17 identifies four electrode plate guides.

21 denotes a metal base plate of a thickness of two millimetres, 22 designates a pressure hole which at the centre of the base plate 21 for introducing the pressure to be measured, 23 represents an electrode terminal pit, 24 shows four screw holes, 25 refers to a bellows which is moved by the introduced pressure, 26 indicates a bellows base which is a circumference of the bellows 25 and is soldered on the base plate 21, 27 identifies a junction of the soldered bellows base 26 and base plate 21 (Fig. 3), and 29 denotes a movable electrode plate which is a disc welded to the centre of the bellows 25.

30 designates a fixed electrode plate which forms a variable capacitance 41 (Fig. 4) with the movable electrode plate 29, 31 represents an electrode terminal which leads an electrode of the fixed electrode plate 30 to the lower part of the housing 10 through the electrode terminal pit 23, 32 shows four positioning holes through which the four electrode guides 17 pass in order to fix the fixed electrode plate 30 to the housing 10 with four fixing rings 34, and 33 refers to a vent which equalizes a pressure of the space between the movable electrode plate 29 and fixed electrode plate 30 to an external pressure. 39 indicates a sealed case which electrically seals by covering the housing 10.

When the pressure supplied from the pressure input 14 becomes higher (lower), the bellows 25 is pushed up (pulled down) so that the distance D shown in Fig. 3 decreases (increases) and the variable capacitance 41 of the pressure sensor 40 shown in Fig. 4 increases (decreases). In Fig. 4, resistors 42 and 43, inverters 44, 45 and 46, and the variable capacitance 41 forms an oscillator which delivers the output signal to an output terminal 47. The pressure being sensed is measured by determining the oscillation frequency from the oscillator.

The main factor by which the value of the variable capacitance 41 is determined is the distance D between the movable electrode plate 29 and the fixed electrode plate 30, as shown in Fig. 3. The distance D mainly depends on the distance d_1 between the base plate 21 and the base or bottom 11 of the housing 10, the thickness d_2 of the junction 27 of the soldered bellows base 26 and base plate 21, and the height d_3 of the upstanding portion 12. Any deviations of these values around the circumference of the device will mean that the value of D is not constant over the surface of the plate 29. This is clearly undesirable, and is likely to result in lower accuracy of pressure measurement.

The base plate 21 is clamped with the screws 38, which are screwed into the screw holes 24, through the through-holes 16, and the O ring 20 is pressed down and deformed. The distance d_1 therefore is close to zero.

Circumferential deviations of the distance d_2 may be caused by variable thicknesses of the solder, since the distance d_2 is the thickness of the junction 27 which is formed with the soldered bellows base 26 and the base plate 21.

The complete hermetic soldering is required all around the circumference of the bellows base 26. The soldering process and subsequent inspection are expensive.

Any deformation of the base plate 21, such as its bending, will cause a change in the distance D. Accordingly, the base plate 21 must consist of a thick metal board. Consequently, the conventional pressure sensor is large and heavy.

The distance d_3, that is the height of the upstanding portion 12 depends upon the housing 10. Since this is formed from a plastics material, of complex shape, deformation after moulding is likely. It is therefore difficult accurately to fix the distance d_3.

The intrinsic uncertainties and circumferential deviations in the distances d_1, d_2 and d_3 combine

be relatively large. So as to produce a reasonably measurable capacitance at 41, the movable electrode plate 29 and the fixed electrode plate need to be large. Furthermore, the use of large plates requires the use of a large base plate 21 and, since the larger the base plate the thicker it needs to be to prevent bending, the depth of the base plate must also be large.

The consequence of this is that conventional sensors must be large, the desirable accuracy still not being available.

An object of the invention is to provide a pressure sensor of small size which is convenient to use.

Another object of the invention is to provide an inexpensive pressure sensor which includes a circuit to detect variations of pressure, for convenience in use.

A further object is to provide a light and small pressure sensor having a small number of parts, and no large metal base; in which soldering of the bellows is not needed; and having a short distance between a movable electrode plate and a fixed electrode plate, the distance between the plates being determined by the thickness of a simple spacing ring.

An additional object is to provide a pressure sensor including a printed circuit board in which a fixed electrode plate and a detection circuit are formed on the under surface and on the upper surface respectively.

In this invention, the main factor contributing to circumferential or other deviations in the distance between the movable electrode plate and the fixed electrode plate is eliminated by the use of a spacer interposed between the bellows and the fixed electrode plate.

According to the present invention a pressure sensor comprises a housing, an aperture in the housing for introducing a pressure to be measured to an enclosed pressure chamber within the housing, the pressure being arranged to act upon one side of a movable bellows having, on the other side thereof, a movable electrode plate, and a fixed electrode plate spaced a desired distance from the movable electrode plate by a spacer interposed between the bellows and the fixed electrode plate.

The invention may be carried into practice in a number of ways and one specific embodiment will now be described by way of example, with reference to the drawings, in which

Figure 1 is an exploded view in perspective of the conventional pressure sensor;

Figure 2 is a sectional side view of the conventional pressure sensor;

Figure 3 is a detailed portion sectional side view of the conventional pressure sensor;

Figure 4 is a conventional circuit diagram for detecting variations of pressure;

Figure 5 is an exploded view in perspective of a pressure sensor in accordance with an embodiment of the present invention; and

Figure 6 is a sectional side view of the pressure sensor of Fig. 5.

With reference to Fig. 5 (an exploded view in perspective) and Fig. 6 (a sectional side view), reference numeral 10A indicates a housing made from, for example, a plastics material of which the outside is plated with metal to obtain an electrical shielding effect. In the inner part of the housing 10A, a round base or bottom portion 11A is provided, in the centre of which there is a pressure hole 15A, to allow for the introduction of the pressure to be measured, via a pressure input 14A. An O ring 20A made from, for example, rubber is located in the base 11A in order to obtain a hermetically sealed space.

A bellows 25A is located on the O ring 20A so that a bellows base 26A, forming the circumference of the bellows 25A, is in hermetic-sealed contact with the O ring 20A. A movable electrode plate 29A is welded at the centre of the bellows 25A. A spacing ring 28A is located on the bellows base 26A.

A printed circuit board 35, on the under surface of which a fixed electrode plate 30A is formed, is located on the spacing ring 28A. The board 35 has four through-holes 36 at the four corners thereof, and is fixed with four screws 38A which are screwed into four screw holes 18A of the housing 10A, through the four through-holes 36.

With such a screwed arrangement, there is no significant deviation of a distance D (not shown) between the movable electrode plate 29A and the fixed electrode plate 30A since, if the screws are firmly tightened up, the under-surface of the printed circuit board 35 will abut the base 10a in the area of the screw holes 18A, as is best seen in Fig. 5. This provides a stop.

The spacing ring 28A, having an important function in at least some aspects of this invention, can be made from plastics or metal. If the fixed spacing ring 34 is made from plastics, all of the surface or some of the surface thereof can be plated in order electrically to connect the movable electrode plate 29A to the under-surface of the printed circuit board 35 through the bellows 25A.

The circuit for detecting variations of pressure (as shown in Fig. 4) is mounted on the upper surface of the printed circuit board 35. The detected output is obtained at an output terminal 47 (Fig. 5), terminals 48 being used for power supply and grounding.

The pressure sensors of Figs. 1 and 5 will now be compared in respect of external dimensions of the housings 10 and 10A, outer diameters of the movable electrode 29 and 29A, outer diameters of the bellows 25 and 25A, and total weights; viz:

	Invention	*Prior Art*
External Dimensions of housings	20 by 20 by 6.5 mm	40 by 40 by 15mm
Movable Electrode Plate Diameters	14mm	29mm
Bellows Diameters	18mm	29mm
Total Weights (Approximately)	4 grams	45 grams

In the above-mentioned external dimensions of the housings, the dimensions of the pressure inputs 14 and 14A and the terminals 47 and 48 are omitted.

It is obvious from the above description that the fixed electrode plate 30A can be formed by etching the laminated copper or joining a metal plate onto the under surface of the printed circuit board 35. In the latter case, soldering or welding is suitable.

The distance D between the movable electrode plate 29A and the fixed electrode plate 30A depends on the spacing ring 28A. Since this has a very simple shape, which can be manufactured to high accuracy, a very small distance can be selected as the distance D.

Thus, the present invention provides a pressure sensor of high reliability, which is very small in size and weight, is inexpensive and convenient to use, and which can be manufactured with a small number of parts, and thus with lower labour costs.

CLAIMS

1. A pressure sensor comprising a housing, an aperture in the housing for introducing a pressure to be measured to an enclosed pressure chamber within the housing, the pressure being arranged to act upon one side of a movable bellows having, on the other side thereof, a movable electrode plate, and a fixed electrode plate spaced a desired distance from the movable electrode plate by a spacer interposed between the bellows and the fixed electrode plate.

2. A pressure sensor as claimed in claim 1 in which the bellows have a generally circular circumferential mounting flange, the spacer comprising a spacing ring interposed between the flange and the fixed electrode plate.

3. A pressure sensor as claimed in claim 1 or claim 2 including an O ring positioned between the bellows and the housing to provide a hermetic seal therebetween.

4. A pressure sensor as claimed in claim 3 in which the housing is generally cup-shaped, the O ring being seated at the base thereof with the bellows seated on the O ring and the spacer seated on the bellows.

5. A pressure sensor as claimed in any one of the preceding claims in which the fixed electrode plate is further positioned to abut a stop on the housing.

6. A pressure sensor as claimed in any one of the preceding claims including securing means arranged to secure the fixed electrode plate to the housing.

7. A pressure sensor as claimed in any one of the preceding claims in which the spacer is of at least partially metallic-coated plastics material.

8. A pressure sensor as claimed in any one of the preceding claims in which the fixed electrode plate comprises or is attached to a printed circuit board.

9. A pressure sensor as claimed in claim 8 in which the printed circuit board includes circuit means arranged to provide an output signal in dependence upon the pressure within the pressure chamber.

10. A pressure sensor substantially as specifically described with reference to Figs. 5 and 6.

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